PB-228 373

DOMESTIC WATER USE IN SUBURBAN HOMES

Richard E. Thomas, et al

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

29 June 1962

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PB 228 373

FINAL REPORT TO

THE FEDERAL HOUSING ADMINISTRATION

DOMESTIC WATER USE IN SUBURBAN HOMES

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TABLE OF CONTENTS

Section	Page No.
INTRODUCTION	1
SOURCES OF DATA	1
PROCESSING OF DATA	3
PRESENTATION OF RESULTS	4
SEASONAL DIFFERENCES	6
EFFECT OF PERSON OCCUPANCY	10
ANNUAL TRENDS	13
APPENDIX	
Bergen County, N. J.	16
Dallas County, Texas	20
Knox County, Tennessee	24
Maricopa County, Arizona	28
Mecklenberg County, N. C.	31
Nueces County, Texas	35
Polk County, Iowa	38
San Diego County, Calif.	41
Santa Clara County, Calif.	45
Wyandotte County, Kansas	49

INTRODUCTION

Starting in 1956 the Federal Housing Administration sponsored a series of studies conducted by the Robert A. Taft Sanitary Engineering Center to develop improved design criteria for soil adsorption systems. As the studies progressed it became evident that much of the information being collected had value beyond its planned use. The Federal Housing Administration amended their sponsorship to include analyses of data for subsidiary information.

Water use data were collected as an integral part of three of the basic studies. The data provide information on domestic water use under a wide range of climatic influences, sources of water supply, and differences in the pattern of usage.

SOURCES OF DATA

Water use information was obtained from municipal and private water companies who served homes in the survey areas. These companies cooperated generously in allowing the use of their records. Data were collected for approximately 1600 homes in 10 counties in 8 states. Many different meter reading periods and consumption recording units, as shown in Table 1, were encountered in these counties. Data were obtained for up to 11 years of record for some subdivisions, but the majority of the data was for periods of less than 5 years.

Table 1

Summary of Data Collection

County	Number of Homes	Years of Records	Reading Period	Units
Bergen, N. J.	97	1955-1960	Quarterly	100's ft^3
Dallas, Texas	495	1955-1959	Monthly	100's gals
Knox, Tenn.	90	1947-1958	Monthly	100's ft^3
Maricopa, Arizona	269	1953-1957	Monthly	100's ft^3 & 1000's gal
Mecklenburg, N. C.	207	1950-1958	Monthly	100's ft^3
Nueces, Texas	56	1948-1953	Monthly	100's gals
Polk, Iowa	37	1952-1959	Quarterly	1000's gals
San Diego, Calif.	164	1949-1958	Bimonthly	100's ft^3
Santa Clara, Calif.	21	1949-1957	Monthly	100's ft^3
Wyandotte, Kansas	167	1955-1959	Bimonthly	100's ft^3
All Counties	1603	1947-1960	-	-

Person occupancy information for each home was also obtained during the course of the individual household sewage disposal system studies. The period of residence was determined to the nearest month for each occupant of a home. From this information it is possible to determine a monthly record of the number of persons residing in each home.

The water use and person occupancy information provide data to evaluate the effect of person occupancy, climatic seasons, and time on water use in suburban homes of the subdivision class. Evaluation of other

factors affecting water use are not within the scope of this report.

PROCESSING OF DATA

Water use and person occupancy data were correlated to obtain paired values for each meter reading period. All water use recording units were reduced to 100's of cubic feet to simplify analysis of the data. The resultant paired values were identified and entered on punch cards. Both values of a pair were omitted whenever invalid or missing data occurred for either value. Person occupancy information was considered invalid when occupancy changed during a reading period. Water use data was considered invalid when use was estimated or when a meter was repaired or reset during a reading period.

A sample data card for quarterly reading periods is described in Table 2. The first six columns identify the card according to subdivision, type of study, location and year of record. Data are entered in columns 7 through 22, and the individual home is identified by the number entered in columns 74 through 77. Data cards for monthly and bimonthly reading periods are the same except that the data are entered in columns 7 through 54 and 7 through 30, respectively.

Table 2

Sample Data Card for a
Quarterly Reading Period

Item	Identification Codes				Quarterly Reading Periods*				Ident.
	Subd.	Study	Loc.	Yr.	1st	2nd	3rd	4th	No.
Cols.	1-2	3	4	5-6	7-10	11-14	15-18	19-22	74-77
Data	32	1	7	59	5/21.0	5/29.0	9999**	6/31.0	32/18

*The first column of each field is the number of persons and the remaining columns are water use in 100's cubic feet.

**Code for invalid or missing data.

A digital computer was employed to process the data. Person occupancy during a reading period was divided into six classes: one person, two persons, three persons, four persons, five persons, and six or more persons. A computer program was devised to obtain the number of observations, mean water use, and variance of the water use for each occupancy class by individual reading periods and by year. Analyses were conducted for each year of record within a subdivision unit followed by a summary of all data for the subdivision. A separate and parallel analysis was conducted to summarize all data within each county. The basic data derived from the computer analysis for all data within each county are summarized in Tables 6 through 14 in the Appendix.

PRESENTATION OF RESULTS

The 10 counties in which data were obtained represent a wide range in climatic conditions which may affect water use. For example, mean annual

rainfall ranges from 8 inches in Maricopa County, Arizona to 48 inches in Knox County, Tennessee. Mean annual temperatures range from 50 degrees in Polk County, Iowa to 69 degrees in Maricopa County, Arizona. Length of growing seasons range from a low of 142 days in Bergen County, New Jersey, to a high of 365 days in San Diego County, California.

Water use data were collected for homes in more than 50 subdivisions encompassing a diversity of architectural designs and living habits. Lot sizes range from 6,000 square feet to 1 acre with a median of about 12,000 square feet. Landscaping was extensive in some subdivisions, while others had little or none. In general the homesites had frequent shrubbery plantings, and the entire lot was maintained in lawn. Water-using appliances include food waste grinders, dishwashers, automatic sequence clothes washers, water softeners, and evaporative-type house coolers as well as the usual bath and kitchen fixtures.

An attempt to separate and identify the effects of the many factors mentioned above is beyond the scope of this report. However, it is of general interest to present specific cases where the effect of one factor or a group of related factors was clearly identified during the collection of data.

Walnut Hills and Midway subdivisions in Dallas County, Texas, were located adjacent to one another under identical climatic conditions, and they received water from the same source. Walnut Hills subdivision had larger lots, more extensive landscaping, and a greater number of water-using appliances in the home. Mean monthly water use for homes with comparable person occupancy is 100 percent greater in Walnut Hills

subdivision than in Midway subdivision. Since climate and water source are identical for the two subdivisions, differences in living habits such as lawn watering and employment of water-using appliances must be largely responsible for the greater water use in Walnut Hills subdivision.

Another point of interest was observed within Walnut Hills subdivision where approximately 20 homes had separate meters for yard irrigation. Total water use for both meters at these homes exceeded the average use at comparable single meter homes by about 70 percent. This difference is not statistically significant for the above data sample, but it does indicate that the use of separate irrigation meters may result in increased total water use.

SEASONAL DIFFERENCES IN WATER USE

Seasonal differences in water use were clearly evident in all 10 counties. Variability in use patterns and meter reading periods made it necessary to assume arbitrary definitions of seasons. The summer season was defined as the three-month period with the greatest water use, and the winter season was defined as the three-month period with the least water use. Exceptions had to be made for counties employing bimonthly and quarterly reading periods. A summary of the months included in the seasons for each county is presented in Table 3. In general the greatest water use occurred in the three month period June, July and August, while the least water use occurred in the three month period December, January, and February.

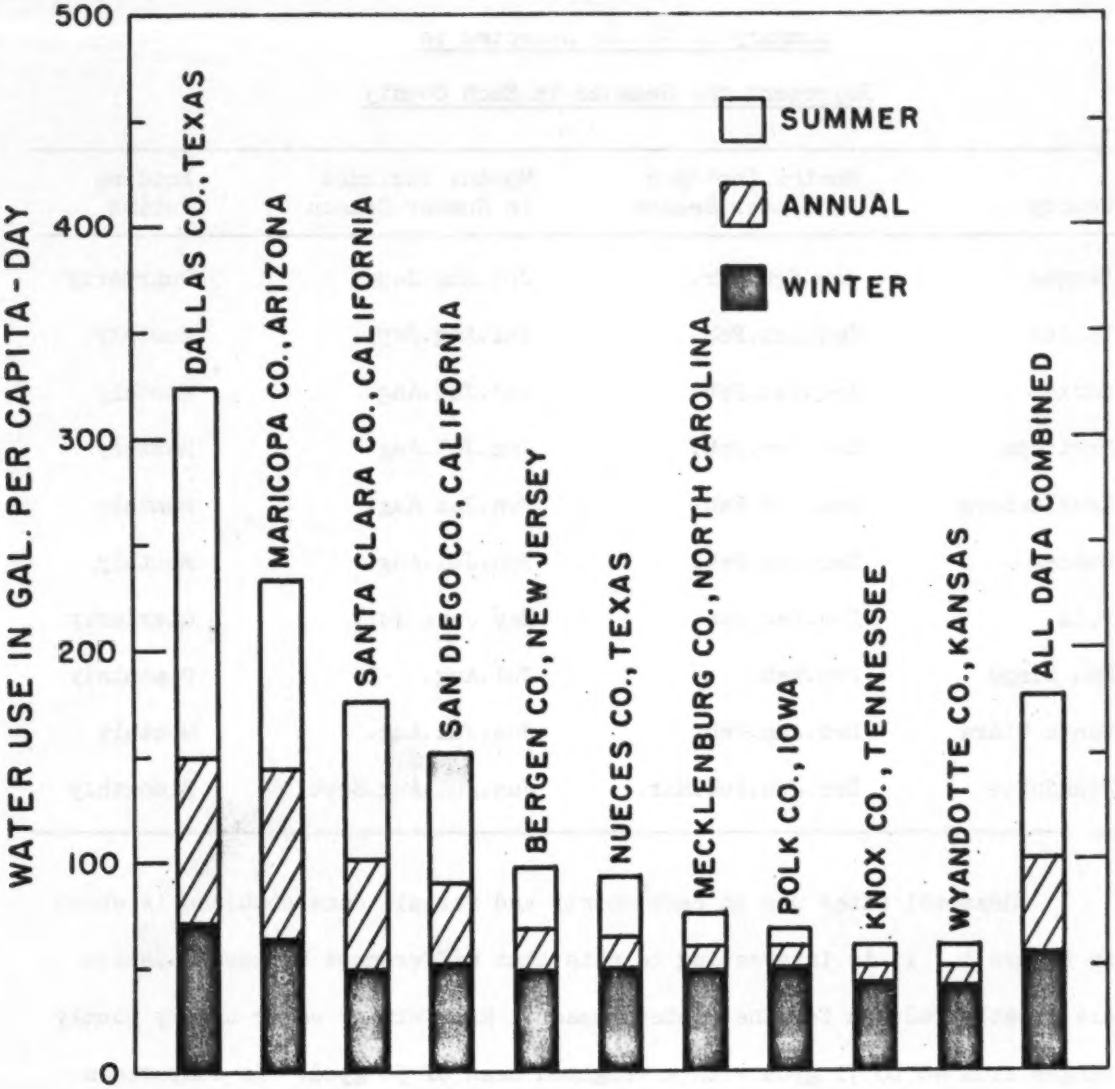
Table 3

Summary of Months Selected to

Represent the Seasons in Each County

County	Months Included in Winter Season	Months Included in Summer Season	Reading Period
Bergen	Jan.Feb.Mar.	Jul.Aug.Sept.	Quarterly
Dallas	Dec.Jan.Feb.	Jul.Aug.Sept.	Monthly
Knox	Dec.Jan.Feb.	Jun.Jul.Aug.	Monthly
Maricopa	Dec.Jan.Feb.	Jun.Jul.Aug.	Monthly
Mecklenburg	Dec.Jan.Feb.	Jun.Jul.Aug.	Monthly
Nueces	Dec.Jan.Feb.	Jun.Jul.Aug.	Monthly
Polk	Nov.Dec.Jan.	May June Jul.	Quarterly
San Diego	Jan.Feb.	Jul.Aug.	Bimonthly
Santa Clara	Dec.Jan.Feb.	Jun.Jul.Aug.	Monthly
Wyandotte	Dec.Jan.Feb.Mar.	Jun.Jul.Aug.Sept.	Bimonthly

Seasonal water use in each county and for all data combined is shown in Figure 1. It is interesting to note that differences between counties are greatly reduced for the winter season. Mean winter water use by county ranges from 40 to 71 gpcd with a weighted mean of 56 gpcd. In comparison mean summer use ranges from 60 gpcd to 324 gpcd with a weighted mean of 178 gpcd. The mean use obtained by taking the arithmetric mean for the 10 individual counties is considerably less than the mean for all data combined because of a bias in sample sizes. Large subsamples of high water use data from Dallas County, Texas, Maricopa County, Arizona and



MEAN WATER USE IN 10 SUBDIVISION AREAS

FIGURE 1

San Diego County, California, comprise about 60 percent of the total sample for all data.

The data presented here show that factors associated with the summer season cause a large increase in water use for some subdivisions but a relatively small increase in others. Increases in summer uses for homes surveyed in the subhumid to arid climates of the southwest are much greater than those in eastern humid climates. The increased water use in these areas may be partially due to the use of evaporation type air conditioning units.

In general the factors contributing to the summer increase within a survey area were not separated and identified during the collection of information, but circumstances were such that the effect of lawn watering was identified in Belden Courts subdivision, Maricopa County, Arizona. A separate source of water was used for lawn watering at 21 of the 58 homes surveyed in this subdivision while the remaining 37 homes used all water from the metered source. The two groups of homes were similar in all respects except for the difference in source of water for lawn irrigation. Mean water use was 30 percent greater during the summer season for the homes using metered water for irrigation. Since all other influencing factors are similar, water use for lawn irrigation in Belden Courts subdivision is not less than 30 percent of the total summer usage. The possibility that some metered water may be used for lawn irrigation at those homes with flood irrigation could result in a greater difference, but it is not probable that this type of use would account for a substantial change.

EFFECT OF PERSON OCCUPANCY ON WATER USE

Analyses of the data for each of the 10 counties (See Appendix) show that water use in one-family suburban homes can be expressed as a linear function of person occupancy. Seasonal equations and associated basic data for each county are presented in Table 4. The linearity of the relationship is not affected by seasonal changes in water use although the intercept and slope may be radically different. It is interesting to note that all of the derived equations have an intercept which is significantly different from zero. The high intercept for the summer season equations may be partially accounted for by water use such as yard irrigation, air conditioning and other factors not directly related to person occupancy. The intercept for winter season equations is less readily explainable, particularly in localities such as Bergen County, New Jersey, and Polk County, Iowa, where winter climates virtually eliminate water use outside the house. It would appear that a substantial fraction of water use within the home is relatively independent of the number of occupants.

Table 4

Equations Expressing Water Use as a Function of Person Occupancy in Gallons Per Home Per Day

County	No. of Homes Surveyed	Mean Person Occupancy	Winter	Summer	Annual
Bergen	97	4.2	Q = 52 + 35 P	Q = 314 + 24 P	Q = 171 + 27 P
Dallas	495	4.0	Q = 116 + 42 P	Q = 917 + 100 P	Q = 404 + 58 P
Knox	90	3.3	Q = 62 + 23 P	Q = 120 + 23 P	Q = 81 + 24 P
Maricopa	269	3.4	Q = 144 + 16 P	Q = 554 + 44 P	Q = 332 + 29 P
Mecklenburg	207	3.3	Q = 75 + 24 P	Q = 190 + 18 P	Q = 123 + 22 P
Nueces	56	3.5	Q = 121 + 14 P	Q = 331 + 0 P	Q = 184 + 10 P
Polk	37	3.5	Q = 112 + 17 P	Q = 126 + 31 P	Q = 144 + 17 P
San Diego	164	3.8	Q = 89 + 28 P	Q = 338 + 43 P	Q = 208 + 34 P
Santa Clara	21	4.3	Q = 41 + 40 P	Q = 223 + 122 P	Q = 130 + 72 P
Wyandotte	167	3.6	Q = 66 + 22 P	Q = 122 + 26 P	Q = 95 + 24 P

Note: Q is water use in gallons per home per day.
P is number of persons occupying home.

Seasonal water use equations for all data combined derived from the data presented in Table 5, are:

Winter	Q = 66 + 38 P
Summer	Q = 166 + 132 P
Annual	Q = 111 + 70 P

Table 5

Relation of Mean Monthly Water Use to Person Occupancy for all Data Combined

Number of Persons	Water Use (Ft^3/Month) Winter		Summer		Annual	
	No. Obs.	Mean Use	No. Obs.	Mean Use	No. Obs.	Mean Use
1	151	520	153	1,450	564	850
2	2,910	570	2,836	1,790	11,209	1,050
3	3,571	710	3,394	2,070	13,503	1,200
4	4,504	930	4,262	2,980	17,503	1,660
5	2,145	1,050	2,006	3,460	8,190	1,930
6 or over	1,321	1,170	1,217	3,660	5,005	2,060

These equations are affected by the bias in sample size distribution discussed in the previous section on seasonal differences in water use. When mean data from each county are given equal weight the equations become:

Winter	Q = 81 + 25 P
Summer	Q = 254 + 57 P
Annual	Q = 152 + 37 P

The mean annual water use for all data combined is 100 gpcd with a mean home occupancy of 3.6 persons. When each county and person occupancy class is given equal weight the mean annual water use is 78 gpcd with a mean occupancy of 3.7 persons.

MacKichan* estimated mean water use from public supplies in the United States at 148 gpcd for 1955. His estimate is obtained from measurement at the source and includes leakage as well as a multitude of uses which are necessary for the normal functioning of a metropolitan complex.

Schwartz, Brady and Silver** conducted an extensive study of domestic water use in Bethlehem, Pennsylvania. Their study shows that average water use for a four-person home in Bethlehem is 48 gpcd. Their results compare favorably with the results obtained herein for localities with similar climatic conditions. For example, water use for four-person homes in Knox County, Tennessee, and Mecklenburg County, North Carolina was found to be 44 and 53 gpcd, respectively.

ANNUAL TRENDS IN WATER USE

Water use records encompassing an eight-year period from 1951 through 1958 were collected for several subdivisions. Data for these subdivisions were separated from the mass of information to observe annual

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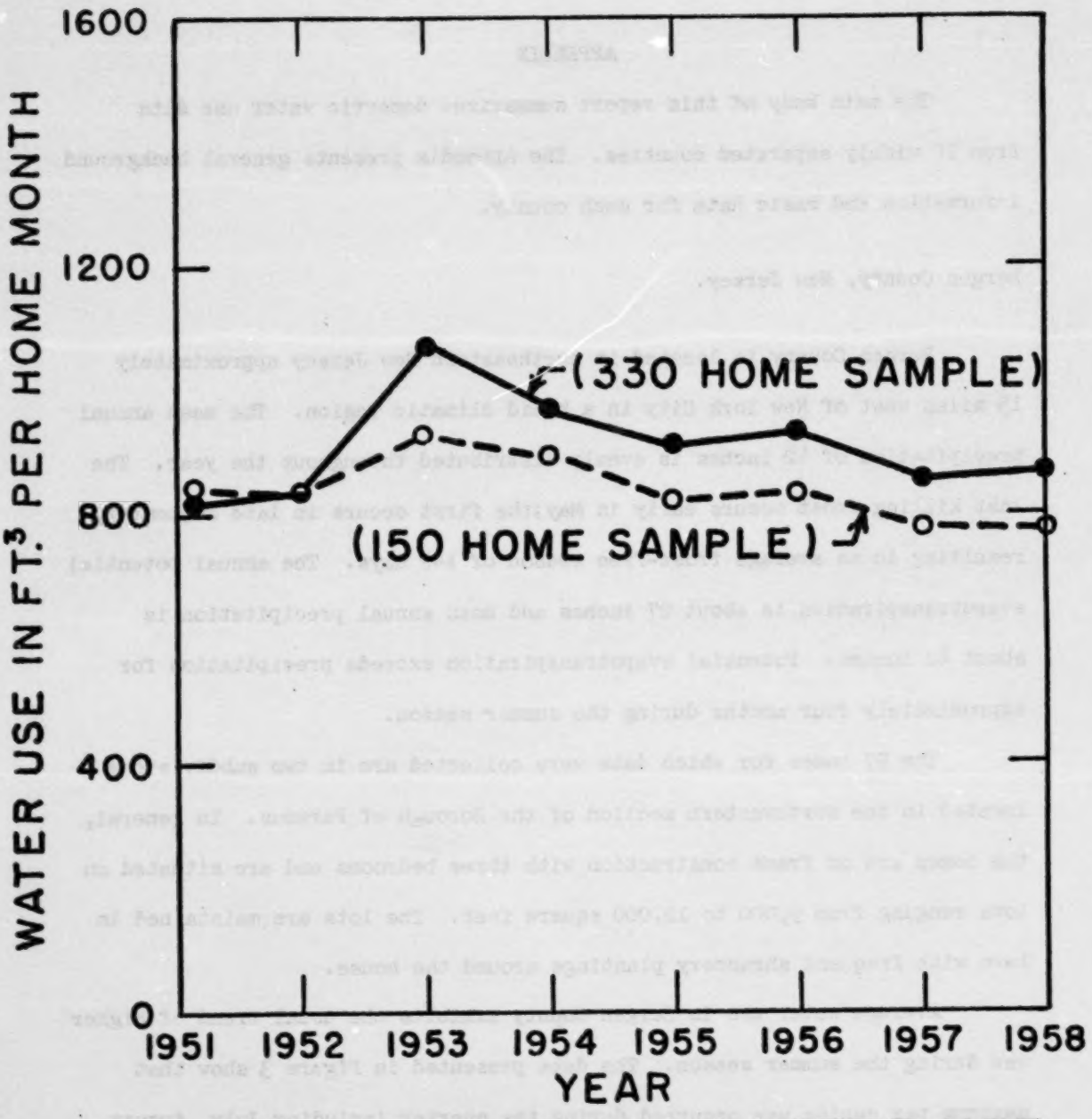
*Kenneth A. MacKichan, Estimated Use of Water in the United States, 1955, p. 1-18, U.S. Geological Survey Circular 398, 1957.

**Eli Schwartz, Francis M. Brady, Jr., and Sidney Silver, Survey of Water Use and Rate Structures at Bethlehem, vol. 15, p. 1235-12346. Journal American Water Works Association, 1959.

trends in water use. The selected sample included approximately 330 homes from subdivisions in San Diego County, California, Knox County, Tennessee, and Mecklenburg County, North Carolina. Results for this data, shown in Figure 2, indicate that there is no observable change in mean annual water use from 1951 to 1958 for these subdivisions. This result occurred despite a 15-percent increase in average person occupancy for this sample over the same time period. The results for a subsample of about 150 homes with constant person occupancy are also shown in Figure 2. The results for this subsample with constant person occupancy also show no relationship between time and water use over the eight year period.



ANNUAL TRENDS IN WATER USE FOR SELECTED SAMPLES

FIGURE 2

APPENDIX

The main body of this report summarizes domestic water use data from 10 widely separated counties. The Appendix presents general background information and basic data for each county.

Bergen County, New Jersey.

Bergen County is located in northeastern New Jersey approximately 15 miles west of New York City in a humid climatic region. The mean annual precipitation of 42 inches is evenly distributed throughout the year. The last killing frost occurs early in May;the first occurs in late September, resulting in an average frost-free season of 142 days. The annual potential evapotranspiration is about 27 inches and mean annual precipitation is about 42 inches. Potential evapotranspiration exceeds precipitation for approximately four months during the summer season.

The 97 homes for which data were collected are in two subdivisions located in the northwestern section of the Borough of Paramus. In general, the homes are of frame construction with three bedrooms and are situated on lots ranging from 9,000 to 12,000 square feet. The lots are maintained in lawn with frequent shrubbery plantings around the house.

Average water use in Bergen County exhibits the usual trend of higher use during the summer season. The data presented in Figure 3 show that maximum per capita use occurred during the quarter including July, August, and September (summer), while mimimum per capita use occurred in the quarter including January, February, and March (winter). Use in the former quarter is approximately double that of the latter.

Mean water use data by persons per home classes are tabulated in Table 6. Plots of mean water use per home versus the number of persons per home show that water use can be expressed as a linear function of the number of persons occupying a home. Seasonal equations, derived from the data presented in Table 6 are:

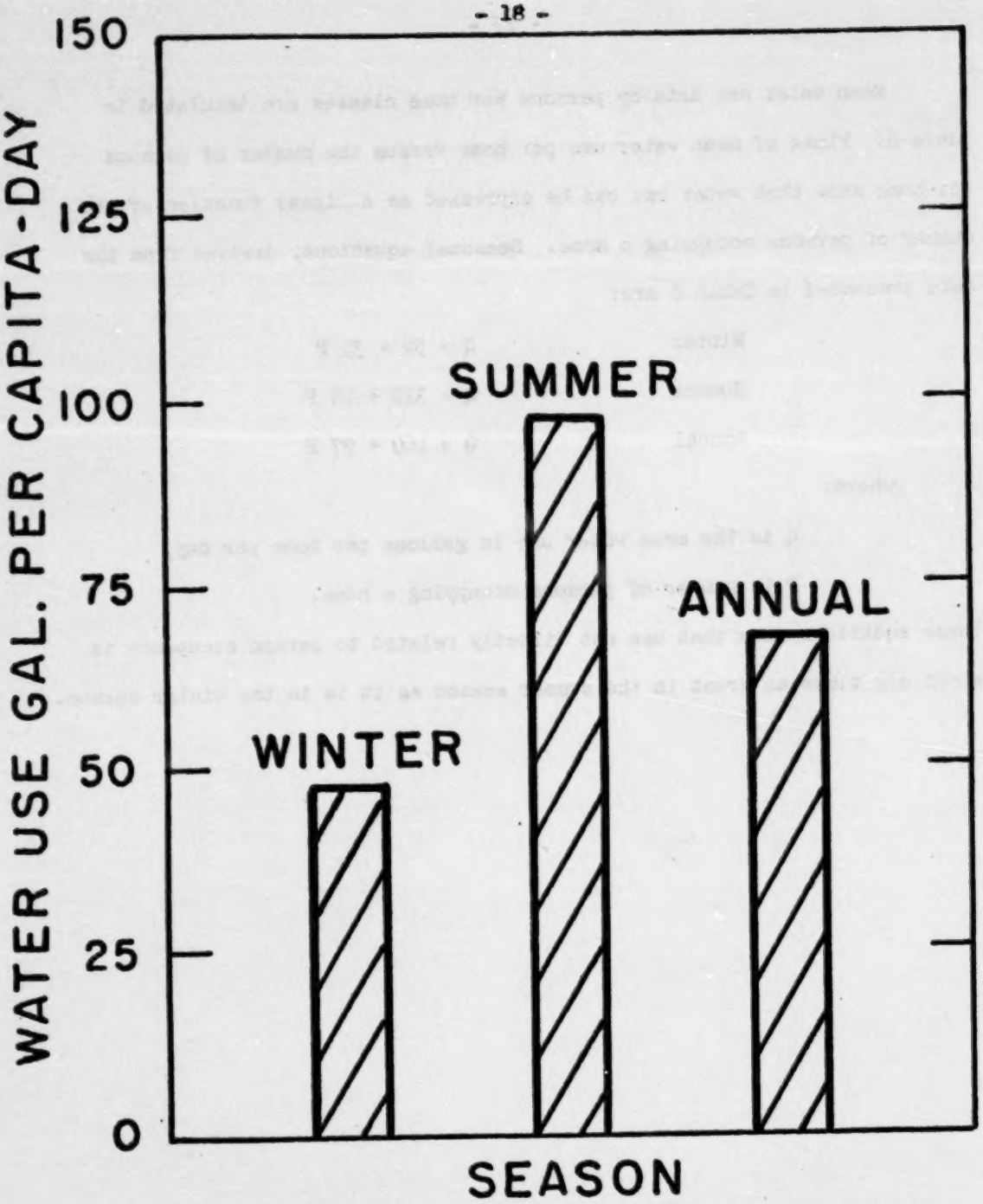
Winter	$Q = 52 + 35\ P$
Summer	$Q = 312 + 24\ P$
Annual	$Q = 169 + 27\ P$

where:

Q is the mean water use in gallons per home per day,

P is number of persons occupying a home.

These equations show that use not directly related to person occupancy is about six times as great in the summer season as it is in the winter season.



WATER USE BY SEASON
BERGEN CO., N.J.

FIGURE 3

Table 6

Relation of Water Use per Home to Number of Occupants
Wynetta Acres and Boulevard Manor Subdivisions
Bergen County, New Jersey

Persons	Item	Jan.Feb.Mar.	Apr.May Jun.	Jul.Aug.Sept.	Oct.Nov.Dec.	Annual
	No. Obs.	6	5	8	8	27
2	Mean Use*	10.0	21.2	41.1	17.4	23.5
	Std. Dev.	2.5	10.0	29.2	6.2	20.2
	No. Obs.	54	52	49	47	202
3	Mean Use*	19.0	32.5	46.2	24.0	30.2
	Std. Dev.	4.8	10.0	17.0	8.1	14.9
	No. Obs.	103	100	112	107	422
4	Mean Use*	25.2	34.6	50.3	28.5	34.9
	Std. Dev.	12.5	11.5	21.6	10.7	17.8
	No. Obs.	73	65	74	73	285
5	Mean Use*	25.3	37.1	52.8	29.8	36.3
	Std. Dev.	9.5	14.1	22.2	9.4	18.2
	No. Obs.	29	25	29	23	106
6	Mean Use*	33.5	40.2	53.8	31.9	40.3
	Std. Dev.	26.8	12.5	22.6	12.4	21.8

*Hundreds of cubic feet per quarter.

Note: No data for one-person occupancy class.

Dallas County, Texas

Dallas County is located in north central Texas at the edge of the subtropical climatic region associated with the Gulf of Mexico. The mean annual rainfall of 35 inches is distributed evenly throughout the year. Mean annual potential evapotranspiration is about 40 inches, and monthly evapotranspiration exceeds rainfall by a substantial margin throughout the long, hot summer season. The average growing season is 250 days extending from mid-March to late November.

Water use data were obtained for 411 homes in Walnut Hills subdivision and 84 homes in Midway subdivision. The three bedroom homes in Walnut Hills subdivision are situated on well-landscaped, one-third of an acre lots. Use of special appliances such as food waste grinders, dishwashers, and house coolers is common in this subdivision. The smaller homes in Midway subdivision are on 7,000 square-foot lots with less landscaping, and with fewer special appliances than commonly used in Walnut Hills subdivision. Per capita water use in these subdivisions is much greater during the summer season as shown in Figure 4. Climatic factors retard the summer season and the greatest water use occurred in July, August, and September. The data presented are for the years 1955 to 1959 and the extremely high summer use may be due in part to a drought which occurred in the mid-1950's.

Mean water use data for persons per home classes are presented in Table 7. These data show clearly that water use per home is directly related to the number of occupants. The following equations are derived

from the data presented in Table 7.

Winter	Q = 117 + 42 P
Summer	Q = 940 + 92 P
Annual	Q = 372 + 58 P

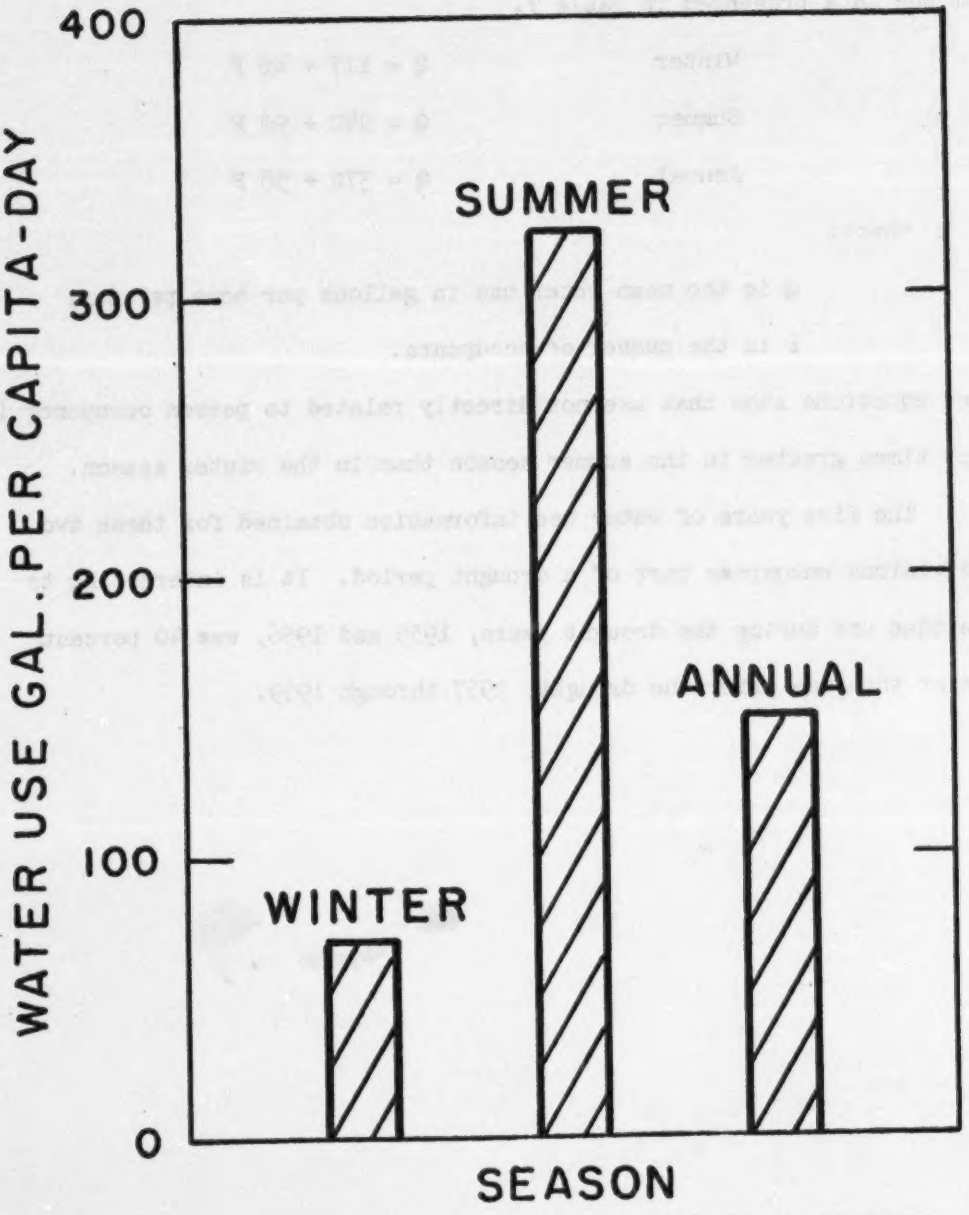
where:

Q is the mean water use in gallons per home per day,

P is the number of occupants.

These equations show that use not directly related to person occupancy is eight times greater in the summer season than in the winter season.

The five years of water use information obtained for these two subdivisions encompass part of a drought period. It is interesting to note that use during the drought years, 1955 and 1956, was 40 percent greater than use after the drought, 1957 through 1959.



WATER USE BY SEASON
DALLAS CO., TEXAS

FIGURE 4

Table 7

Relation of Water Use per Home to Number of Occupants
Walnut Hills and Midway Subdivisions
Dallas County, Texas

Persons	Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
	No. Obs.	19	19	19	20	20	18	17	17	16	15	15	15	210
1	Mean Use*	4.2	3.1	3.2	5.1	8.5	15.4	17.4	23.3	24.5	15.4	6.7	12.8	11.2
	Std. Dev.	4.3	3.1	2.7	6.9	14.4	23.2	16.4	25.2	27.4	25.1	5.6	33.6	19.2
	No. Obs.	195	190	188	191	193	184	169	152	145	145	142	141	2035
2	Mean Use*	8.8	6.4	6.6	10.7	14.7	20.6	33.8	50.0	47.9	23.0	11.8	7.3	19.3
	Std. Dev.	10.6	5.6	4.0	10.8	13.8	18.6	29.4	32.8	29.6	19.9	10.1	5.8	23.2
	No. Obs.	285	281	281	285	279	257	237	222	218	224	226	226	2973
3	Mean Use*	11.5	9.1	9.7	13.5	17.1	23.4	37.8	56.1	51.5	25.4	13.3	10.5	22.1
	Std. Dev.	9.0	6.0	9.4	11.0	12.6	17.1	25.9	32.3	28.4	18.2	9.9	7.0	22.9
	No. Obs.	661	666	668	670	669	599	528	522	516	520	522	521	6984
4	Mean Use*	13.2	10.6	10.7	14.9	19.6	28.8	44.2	63.8	59.0	30.6	15.7	12.3	25.6
	Std. Dev.	8.9	7.4	7.4	11.4	14.8	20.5	29.6	33.0	30.6	21.3	10.8	8.8	35.6
	No. Obs.	338	342	342	351	352	315	289	274	269	275	270	273	3680
5	Mean Use*	14.2	11.5	12.1	16.8	21.0	31.4	48.4	65.8	59.4	31.3	17.8	13.7	27.4
	Std. Dev.	6.8	4.8	5.4	10.3	13.8	21.0	28.5	30.0	26.2	16.7	12.4	7.4	36.7
	No. Obs.	230	231	233	236	235	207	188	181	187	191	189	195	2455
6	Mean Use*	15.5	13.1	13.5	17.4	21.7	32.3	44.7	63.1	60.9	32.7	17.9	14.6	27.7
	Std. Dev.	7.7	6.4	6.7	10.5	12.3	19.2	27.0	28.5	29.9	20.2	9.9	7.9	23.9

*Hundreds of cubic feet per month.

Knox County, Tennessee

Knox County is located in central Tennessee in the humid climatic region. The mean annual rainfall of 48 inches is evenly distributed throughout the year. Mean annual evapotranspiration is about 32 inches. Monthly evapotranspiration exceeds the monthly rainfall for about six months of the year. The average growing season is about 220 days extending from early in April to early in November.

Water use data for 90 homes were obtained in Clearview Hills and Colonial Village subdivisions. The two-to-three bedroom, brick and frame homes in both subdivisions are situated on lots ranging from one-third to one-half acre. Yards are usually maintained in well-established lawns with frequent shrubbery plantings. Only a few homes are equipped with appliances such as food waste grinders and water softeners.

Seasonal differences in water use are not extreme as shown in Figure 5. Mean water use in the summer months of June, July, and August is only about 40 percent greater in the winter months of December, January, and February.

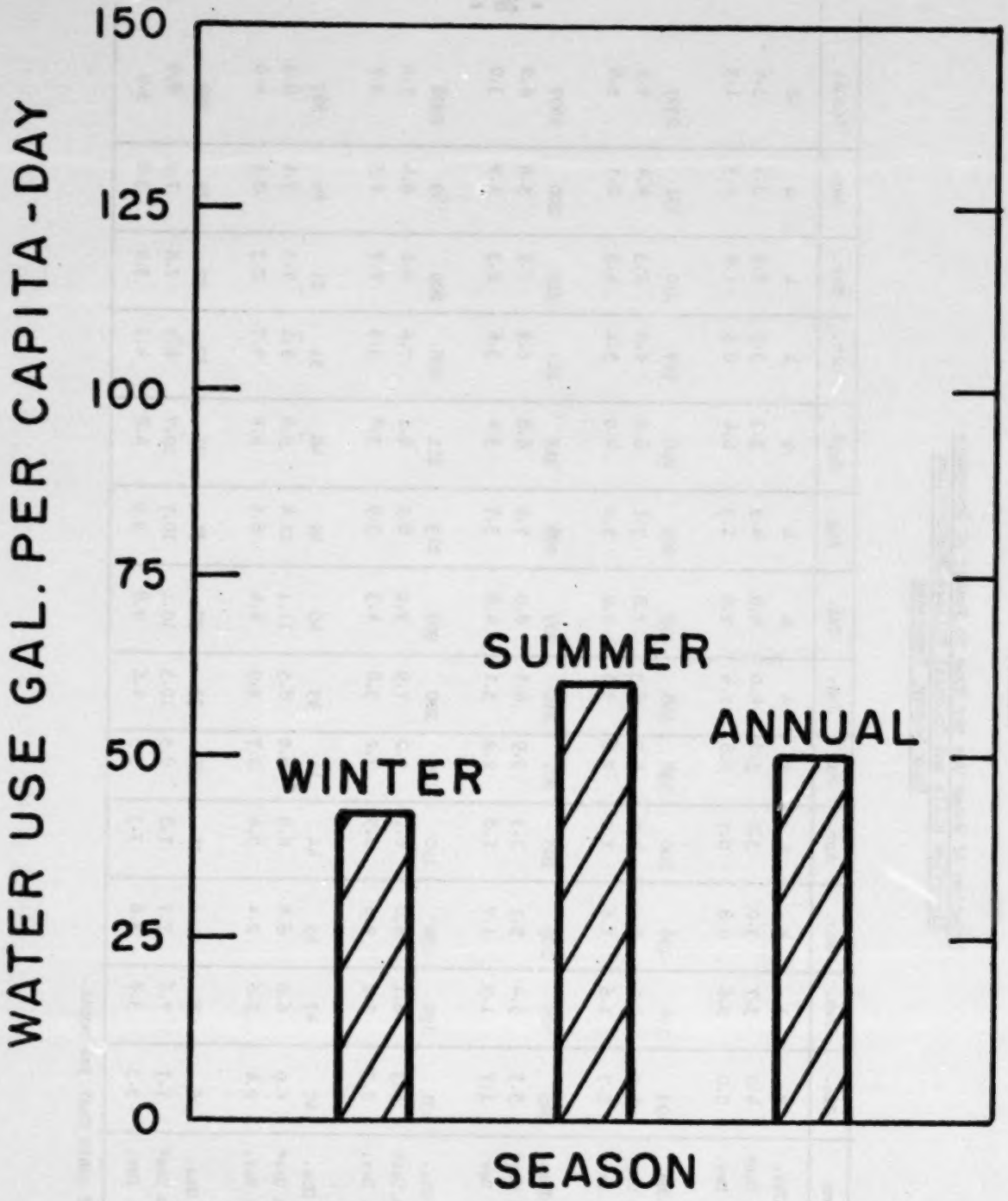
Mean water use per home for six person-occupancy classes is shown in Table 8. These data show that water use is strongly related to the number of occupants. Seasonal equations, derived from the data presented in Table 8, are:

Winter	$Q = 62 + 23\ P$
Summer	$Q = 120 + 23\ P$
Annual	$Q = 81 + 24\ P$

where:

Q is the mean water use in gallons per home per day,

P is the number of home occupants.



WATER USE BY SEASON
KNOX CO., TENN.

FIGURE 5

Table 8

Relation of Water Use per Home to Number of Occupants
Clearview Hills and Colonial Village Subdivisions
Knox County, Tennessee

Persons	Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1	No. Obs.	3	3	4	5	5	4	4	4	4	4	4	4	48
	Mean Use*	4.0	3.7	3.0	3.0	3.8	4.0	4.8	4.3	3.3	3.5	3.3	3.5	3.6
	Std. Dev.	0.0	0.6	0.8	0.7	0.8	1.4	2.9	1.3	0.4	0.5	1.5	1.3	1.3
2	No. Obs.	193	194	198	200	196	198	199	205	206	207	210	191	2397
	Mean Use*	4.2	4.1	4.0	4.2	5.3	6.3	7.8	7.1	6.2	6.0	5.3	4.4	5.4
	Std. Dev.	1.7	1.6	1.6	1.9	2.6	3.6	5.2	5.1	4.0	5.1	4.3	2.1	3.8
3	No. Obs.	205	205	209	205	201	210	209	208	212	215	219	200	2497
	Mean Use*	5.5	5.4	5.1	5.3	5.9	6.5	8.0	7.0	6.8	6.9	5.9	5.6	6.2
	Std. Dev.	1.7	1.9	1.7	1.8	2.2	3.1	4.8	3.7	3.4	3.6	2.3	1.9	3.0
4	No. Obs.	191	190	194	190	196	200	207	213	211	208	209	189	2398
	Mean Use*	6.3	6.1	6.0	6.1	7.0	7.9	9.2	8.5	8.1	7.6	6.6	6.4	7.2
	Std. Dev.	2.3	2.1	2.6	2.5	3.2	3.8	4.3	3.9	3.8	3.3	2.7	2.3	3.2
5	No. Obs.	47	47	45	44	44	45	46	49	48	51	51	46	563
	Mean Use*	6.9	6.8	6.8	6.8	8.0	8.5	11.1	11.4	9.0	9.1	7.3	7.1	8.3
	Std. Dev.	2.4	2.6	2.4	2.4	2.7	2.9	4.4	6.6	4.4	4.7	2.3	2.6	4.0
6 or over	No. Obs.	26	28	29	31	31	33	30	31	31	32	32	25	359
	Mean Use*	7.7	7.6	7.7	7.8	8.5	10.3	10.1	10.7	10.7	8.9	7.8	7.9	8.9
	Std. Dev.	3.3	3.8	3.6	3.3	3.5	4.6	2.8	3.9	4.8	4.5	3.5	3.8	3.9

*Hundreds of cubic feet per month.

It is interesting to note that the slope factor is the same in all three equations. Differences between seasonal water use is thus independent of the number of occupants in the home.

Water use records for about 50 homes were obtained over a 10-year period from 1949 to 1958. Average person occupancy in the homes remained constant over this period. Water use in cubic feet per home per month ranged from a low of 520 in 1950 to high of 670 in 1954 with an over-all mean of 600 cubic feet per home per month. Mean use over the first 5 years of the period averaged 580 cubic feet per home per month while mean use over the last 5 years averaged 610 cubic feet per home per month.

Maricopa County, Arizona

Maricopa County is located in central Arizona in the arid southwest. The mean annual rainfall is 8 inches, while mean annual potential evapotranspiration is 44 inches. The average growing season of 304 days extends from early February to early December, and monthly potential evapotranspiration exceeds monthly rainfall throughout this season.

Water use information was collected for 269 homes from 7 different subdivisions. House size and style varied as did lot size and landscaping. The median home was a three-bedroom ranch-style house located on a 10,000-square-foot lot maintained in good lawn with several shrubs and trees. Nearly all homes were equipped with evaporative house coolers which added considerably to water use in the summer months. Use of other appliances such as food waste grinders and water softeners varied from 0 to 40 percent within subdivisions. Over-all, 10 percent of the homes were equipped with food waste grinders and 15 percent were equipped with water softeners.

Seasonal differences in water use are very pronounced in Maricopa County. Use during the summer months of June, July,and August, as shown in Figure 6, is four times greater than use in the winter months of December, January, and February. Evaporation-type house coolers contribute substantially to summer use.

Water use information for Maricopa County has been presented in a previous report.* Equations from that report are:

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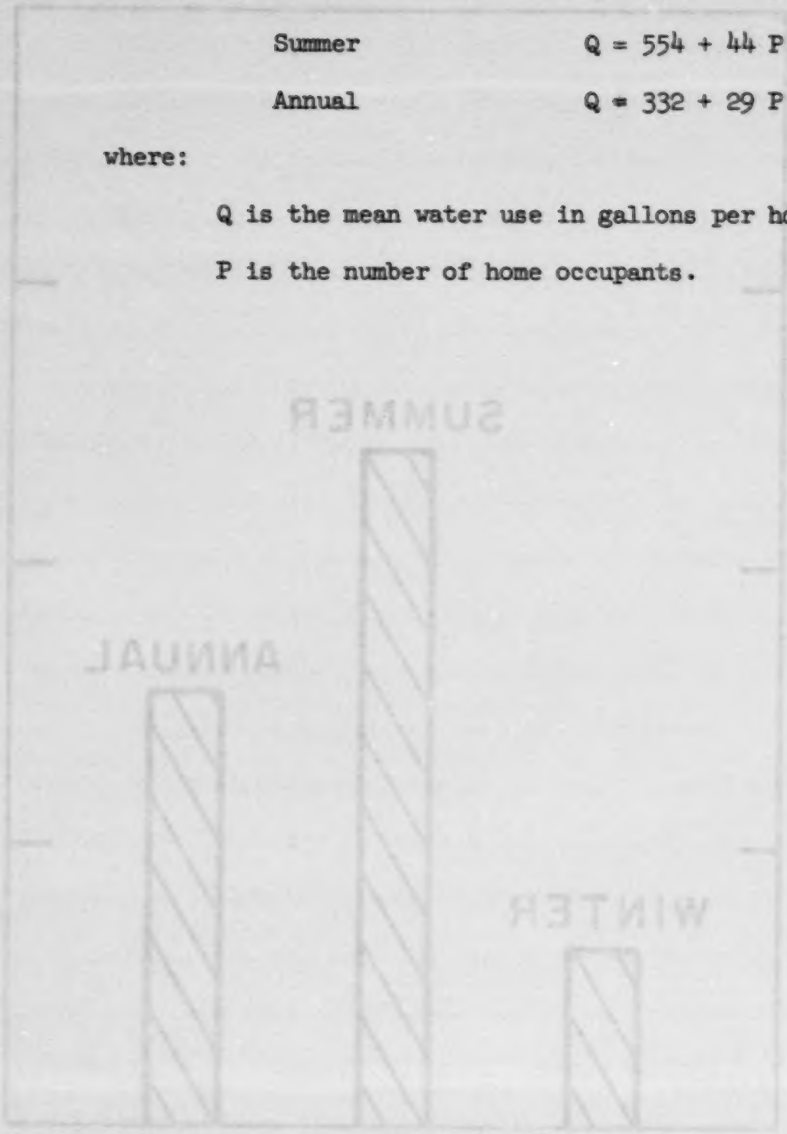
*Domestic Water Use in Phoenix, Arizona. Report to the Federal Housing Administration, Robert A. Taft Sanitary Engineering Center, June 15, 1959.

Winter	Q = 144 + 16 P
Summer	Q = 554 + 44 P
Annual	Q = 332 + 29 P

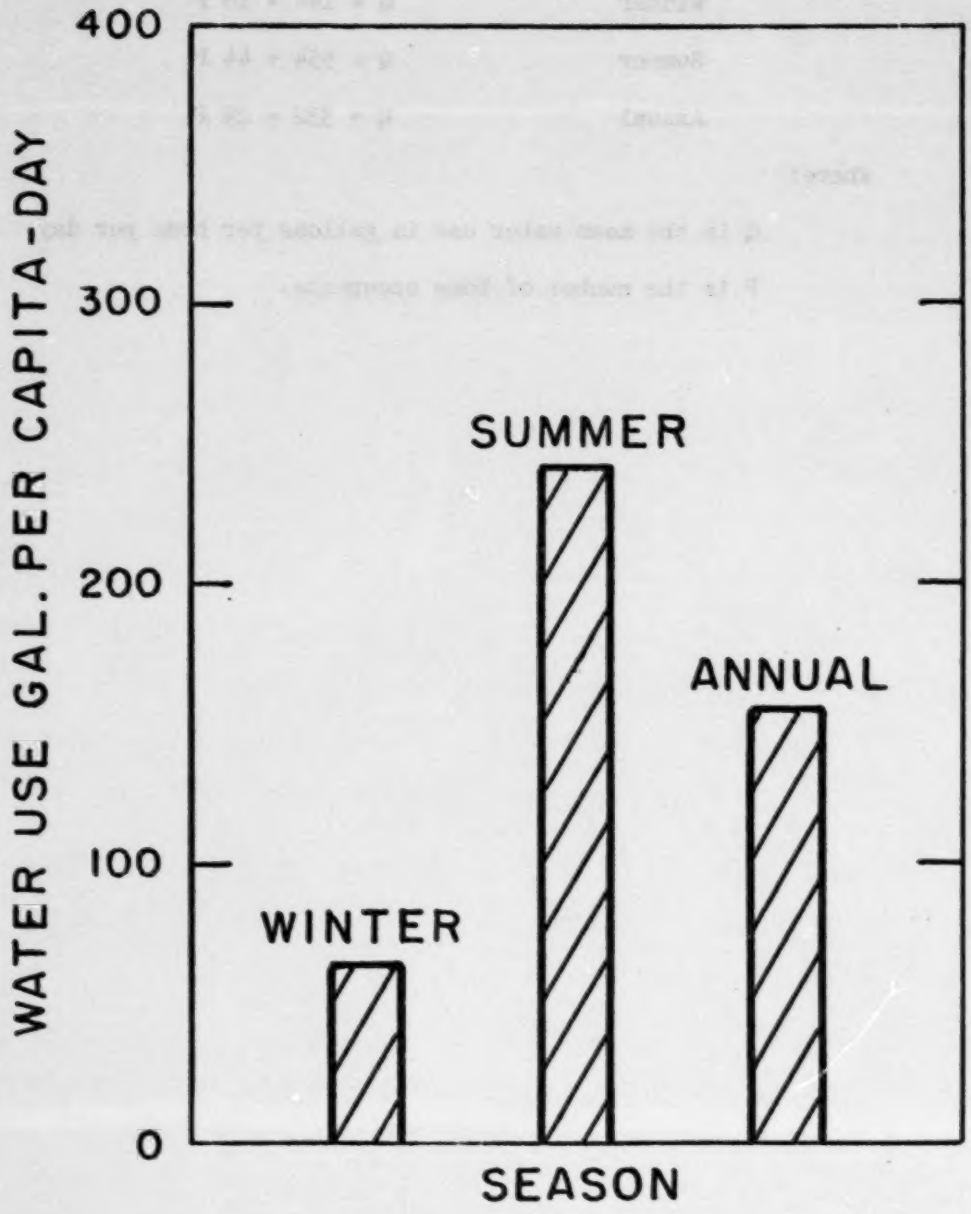
where:

Q is the mean water use in gallons per home per day,

P is the number of home occupants.



WATER USE BY SEASON
MARICOPA CO., ARIZ.
FIGURE 6



WATER USE BY SEASON
MARICOPA CO., ARIZ.

FIGURE 6

Mecklenburg County, North Carolina

Mecklenburg County is located in south central North Carolina in the eastern humid climatic region. The mean annual rainfall of 45 inches is evenly distributed throughout the year. Mean annual potential evapotranspiration is 34 inches, and monthly potential evapotranspiration exceeds monthly rainfall from May through September. The average growing season is 240 days extending from mid-March to mid-November.

Water use information was obtained for 207 homes located in four subdivision areas representing a wide range in home building practices. The 2- to 4-bedroom houses are situated on 8,000 to 20,000-square-foot lots. Landscaping varies considerably as does the use of special water-using appliances. Over-all, 20 percent of the homes are equipped with food waste grinders and 30 percent have dishwashers.

The relation of seasons to water use is presented in Figure 7. Mean summer use is approximately 60 percent greater than winter use. The months included in the summer season are June, July, and August, while the months included in the winter season are December, January, and February.

Mean water use data for six person-occupancy classes are given in Table 9. These data show that water use throughout the year is directly related to the number of occupants. Plots of water use per home versus the number of occupants show that this relationship can be expressed linearly. Seasonal equations, derived from the data in Table 9, are:

Winter	$Q = 75 + 24\ P$
Summer	$Q = 190 + 18\ P$
Annual	$Q + 121 + 22\ P$

where:

Q is the mean water use in gallons per home per day,

P is the number of home occupants.

The major difference in the equations for summer and winter use is in the intercept which represents water use not directly related to the number of occupants.

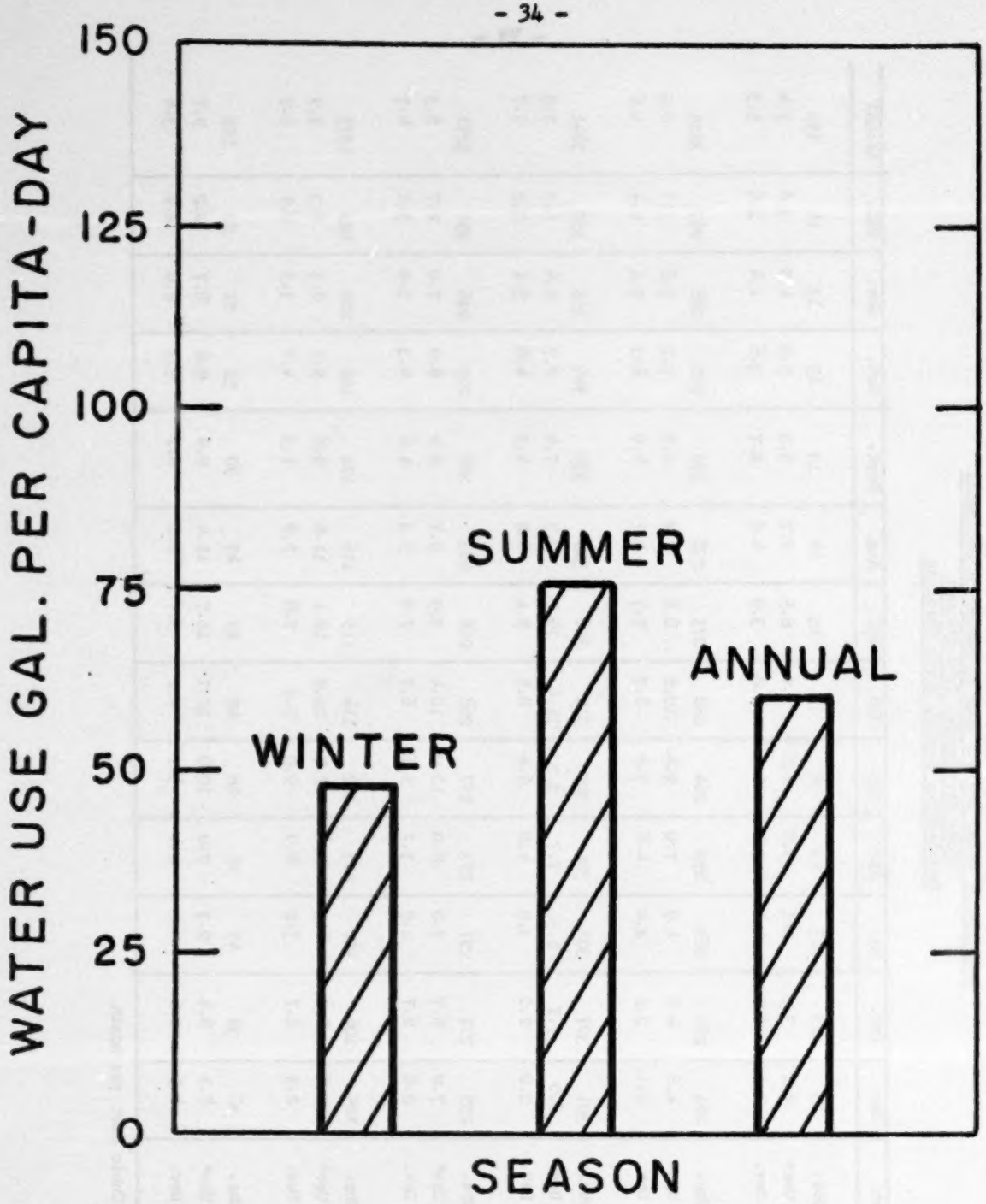
Water use data for about 40 homes were obtained over an eight-year period from 1951 to 1958. Use in cubic feet per home per month ranged from a low of 640 in 1958 to a high of 940 in 1953. Use from 1951 through 1954 was greater than the over-all mean of 770 cubic feet per home per month, while use from 1955 through 1958 was below the over-all mean.

Table 9

Relation of Water Use per Home to Number of Occupants
Four Residential Subdivisions
Mecklenburg County, North Carolina

Persons	Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
1	No. Obs.	13	13	13	13	14	13	13	14	13	13	13	14	159
	Mean Use*	4.1	3.9	4.1	5.8	6.6	7.1	6.5	7.7	5.3	5.0	4.5	3.6	5.4
	Std. Dev.	1.5	1.5	1.4	3.6	4.5	4.8	3.9	4.6	2.7	3.6	1.4	1.6	3.3
2	No. Obs.	261	262	260	259	264	268	273	278	276	280	286	287	3254
	Mean Use*	4.8	4.8	4.9	7.0	9.4	10.6	8.8	7.9	6.5	7.1	5.6	5.1	6.9
	Std. Dev.	2.1	2.2	2.4	4.6	7.9	8.7	7.7	4.7	4.9	6.3	3.1	2.4	5.6
3	No. Obs.	301	307	303	306	305	310	308	316	336	346	353	350	3841
	Mean Use*	6.0	5.7	6.3	7.7	9.7	11.0	10.1	9.9	7.4	7.7	6.4	6.3	7.8
	Std. Dev.	2.0	2.0	3.2	4.8	6.4	8.5	9.1	8.0	4.5	4.6	3.1	2.3	5.7
4	No. Obs.	255	257	257	253	257	268	268	283	286	295	296	296	3271
	Mean Use*	7.0	6.7	7.0	8.0	10.0	10.4	9.9	9.7	8.2	8.0	7.0	7.7	8.3
	Std. Dev.	2.8	2.7	2.9	3.7	5.6	6.7	7.0	5.3	4.6	4.3	3.0	3.2	4.7
5	No. Obs.	105	106	107	108	112	114	115	116	121	122	122	125	1373
	Mean Use*	7.8	8.0	8.3	9.7	12.7	12.9	12.1	11.8	9.6	9.5	8.3	8.3	9.9
	Std. Dev.	2.3	2.7	3.2	4.9	9.0	9.2	7.8	5.9	5.3	4.7	3.3	2.5	5.9
6 or over	No. Obs.	38	39	45	45	46	45	45	47	50	51	51	50	552
	Mean Use*	8.5	8.4	9.3	9.0	10.0	10.7	11.7	11.4	9.9	9.0	8.7	9.2	9.7
	Std. Dev.	2.5	2.6	3.0	2.4	3.1	4.2	5.7	4.0	4.2	3.3	2.6	2.9	3.6

*Hundreds of Cubic Feet per month.



WATER USE BY SEASON
MECKLENBURG CO., N.C.

FIGURE 7

Nueces County, Texas

Nueces County is in southern Texas on the Gulf of Mexico. The climate is intermediate between subtropical and semiarid. The mean annual rainfall of 26 inches is evenly distributed throughout the year. Mean annual potential evapotranspiration is 46 inches, and the monthly values exceed monthly rainfall from March through November. The average growing season is about 335 days extending from late January to late December.

Water use data were obtained for 56 homes in Ebony Acres subdivision for the years 1948 through 1953. The 2-bedroom frame houses in this subdivision are located on 9,000-square-foot lots. Very few of the homes are equipped with special water-using appliances such as garbage grinders, dishwashers, etc.

Seasonal water use is shown graphically in Figure 8. Use in the summer season (June, July, and August) is approximately double the use in the winter season (December, January, and February).

Mean water use for five person-occupancy classes is presented in Table 10. Water use equations, derived from these data are:

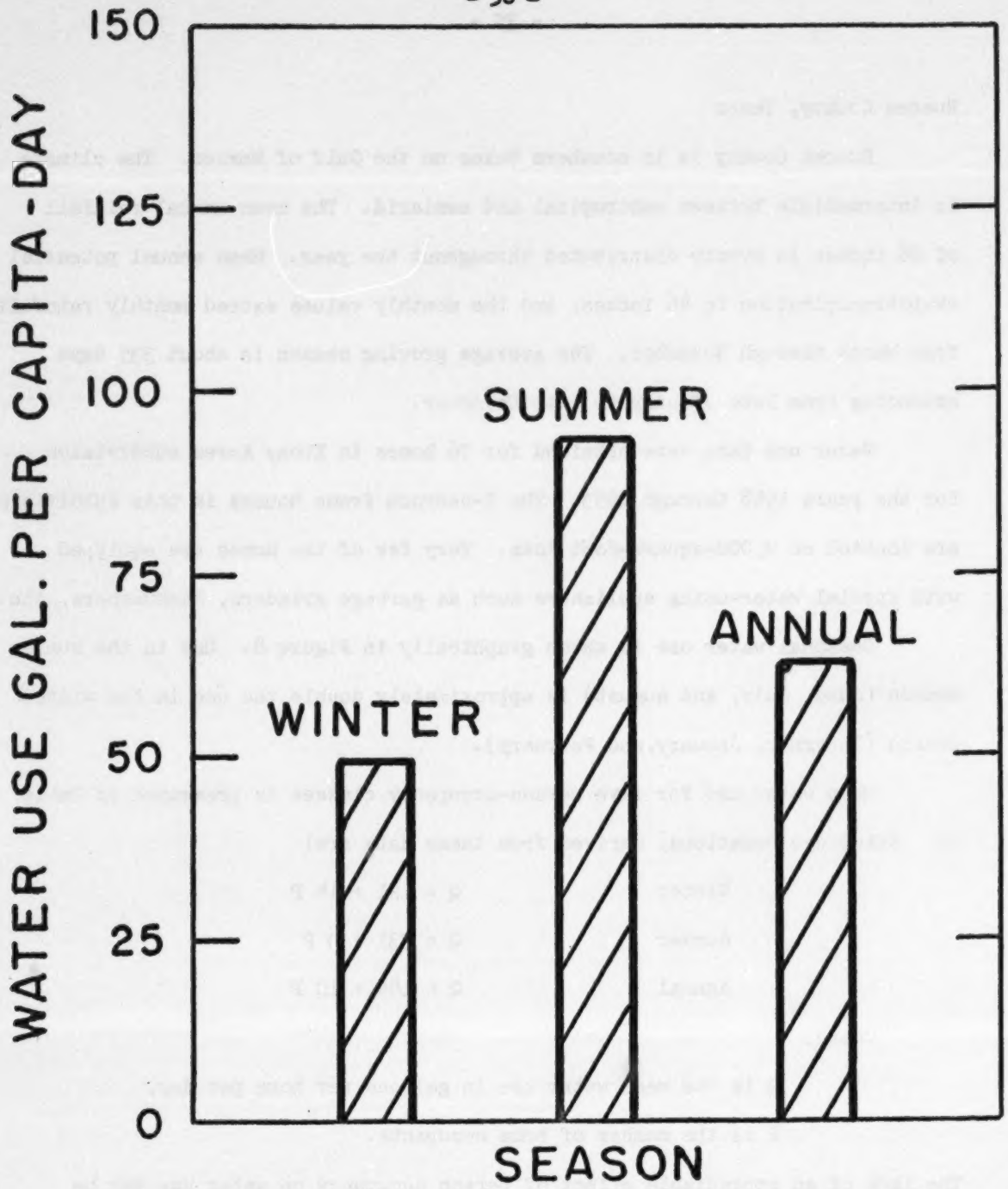
Winter	$Q = 121 + 14\ P$
Summer	$Q = 331 + 0\ P$
Annual	$Q = 184 + 10\ P$

where:

Q is the mean water use in gallons per home per day,

P is the number of home occupants.

The lack of an appreciable effect of person occupancy on water use may be partially due to the large numbers of the homes experiencing septic tank failures. Because of continuous failing systems, individual water use habits may have been altered in an attempt to conserve water and reduce failure problems.



WATER USE BY SEASON
NUECES CO., TEXAS

FIGURE 8

Table 10

Relation of Water Use per Home to Number of Occupants
Ebony Acres Subdivision
Nueces County, Texas

Persons	Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
	No. Obs.	31	30	30	21	23	21	21	24	26	28	30	32	317
2	Mean Use*	7.0	7.5	7.0	7.4	8.3	10.9	14.7	12.8	10.1	6.7	5.1	4.8	8.2
	Std. Dev.	3.2	3.7	3.3	4.4	3.0	5.9	7.9	6.4	5.6	3.3	2.0	2.0	5.1
	No. Obs.	52	52	52	39	41	41	43	44	44	42	47	47	544
3	Mean Use*	6.3	8.1	8.0	7.4	9.8	13.3	16.3	14.3	11.2	6.1	5.3	4.6	9.1
	Std. Dev.	2.5	4.1	3.5	3.3	3.7	5.7	8.1	5.9	5.2	3.1	2.5	1.6	5.7
	No. Obs.	44	43	45	33	34	34	35	35	36	37	39	40	455
4	Mean Use*	7.0	9.2	8.0	7.7	8.9	11.8	13.9	11.8	10.5	6.9	6.0	5.0	8.8
	Std. Dev.	2.4	4.8	3.1	3.6	3.1	4.8	6.0	6.3	4.8	4.3	3.2	2.6	4.9
	No. Obs.	13	13	14	8	9	9	12	12	13	12	12	12	139
5	Mean Use*	7.5	10.8	7.9	8.0	7.8	9.8	11.6	11.8	11.3	7.7	6.5	6.2	9.0
	Std. Dev.	2.0	5.3	1.8	2.3	2.7	3.5	4.6	5.4	3.3	2.7	1.7	1.7	3.8
	No. Obs.	15	15	15	9	10	10	10	10	10	10	11	11	136
6 or over	Mean Use*	8.8	9.8	9.5	10.1	12.4	13.8	18.0	15.2	12.8	8.4	6.9	6.3	10.8
	Std. Dev.	2.5	3.3	4.7	4.4	4.5	7.5	9.6	7.2	4.8	4.5	2.6	1.6	5.8

*Hundreds of cubic feet per month.

Note: No data for one-person occupancy class.

Polk County, Iowa

Polk County is in south central Iowa at about the boundary line between humid and subhumid climatic regions. The mean annual rainfall is 31 inches, and mean annual potential evapotranspiration is 27 inches. Monthly potential evapotranspiration exceeds monthly rainfall for about four months in the summer season. The annual growing season of about 175 days begins in mid-April and ends in mid-October.

Water use data were obtained for 37 homes which were selected from several subdivisions. House size, lot size, and degree of landscaping varied considerably. About one-half of the homes were equipped with food waste grinders and water softeners.

Mean seasonal water use for the sample is shown in Figure 9. The quarters including May, June, and July and November, December, and January were selected to represent summer and winter, respectively. Water use in the summer period is about 40 percent greater than use in the winter period.

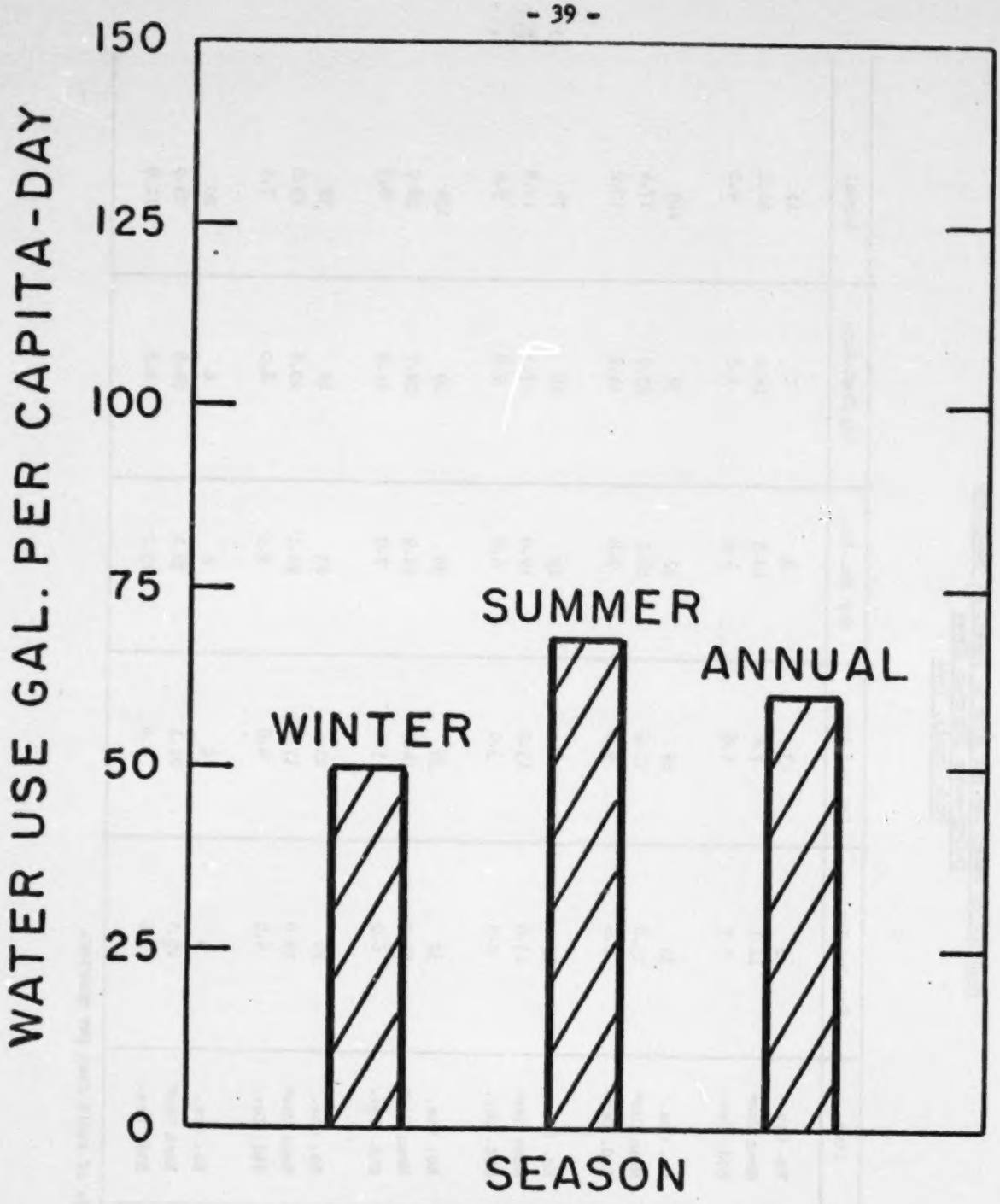
Mean quarterly water use data for six person-occupancy classes are presented in Table 11. Quarterly water use versus person occupancy show a linear relationship represented below.

Winter	$Q = 112 + 17\ P$
Summer	$Q = 126 + 31\ P$
Annual	$Q = 144 + 17\ P$

where:

Q is the mean water use in gallons per home per day,

P is the number of home occupants.



WATER USE BY SEASON
POLK CO., IOWA

FIGURE 9

Table 11

Relation of Water Use per Home to Number of Occupants
Thirty-seven Suburban Homes
Polk County, Iowa

Persons	Item	Nov.Dec.Jan.	Feb.Mar.Apr.	May Jun.Jul.	Aug.Sept.Oct.	Annual
1	No. Obs.	3	3	3	2	11
	Mean Use*	11.1	7.6	10.5	14.4	10.6
	Std. Dev.	5.7	1.6	4.2	1.8	4.0
2	No. Obs.	31	29	32	32	124
	Mean Use*	13.8	11.6	18.1	25.7	17.4
	Std. Dev.	8.6	9.9	9.8	14.8	12.2
3	No. Obs.	19	18	19	18	74
	Mean Use*	13.8	13.2	19.0	17.3	15.8
	Std. Dev.	2.5	3.0	6.8	5.8	5.4
4	No. Obs.	32	35	38	29	134
	Mean Use*	15.2	14.7	22.9	22.7	18.9
	Std. Dev.	6.2	5.6	7.9	11.0	8.7
5	No. Obs.	19	21	23	16	79
	Mean Use*	19.0	17.4	22.1	20.8	19.8
	Std. Dev.	6.2	4.8	9.5	8.0	7.5
6 or over	No. Obs.	4	6	6	4	20
	Mean Use*	18.5	21.1	36.4	24.8	25.9
	Std. Dev.	8.6	9.6	13.7	4.6	11.9

*Hundreds of cubic feet per quarter.

San Diego County, California

San Diego County is located in the extreme southwestern United States. The Pacific Ocean moderates the arid climate along the coastline resulting in a wide range of climatic conditions within the County. Mean annual rainfall is 11 inches, and mean annual potential evapotranspiration is about 32 inches. Monthly potential evapotranspiration exceeds monthly rainfall throughout the long, dry summer season. The growing season along the coast is 365 days, while the growing season 15 miles inland is about 275 days.

Water use information was obtained for 164 homes encompassing many small subdivisions. The two-to four-bedroom ranch-style houses were situated on lots ranging from 6,000 to 12,000 square feet. Landscaping was extensive at some homes while others had little or none. Use of special water-using appliances also varied considerably. Over-all, 40 percent of the homes had food waste grinders, and 50 percent had water softeners.

Mean seasonal water use is shown in Figure 10. The bimonthly reading period of January and February was selected to represent winter, and the bimonthly reading period of July and August was selected to represent summer. Water use during the summer period is two and one-half times as great as use in the winter period.

Mean bimonthly water use for six person-occupancy classes is given in Table 12. Equations derived from the data presented in Table 12, are:

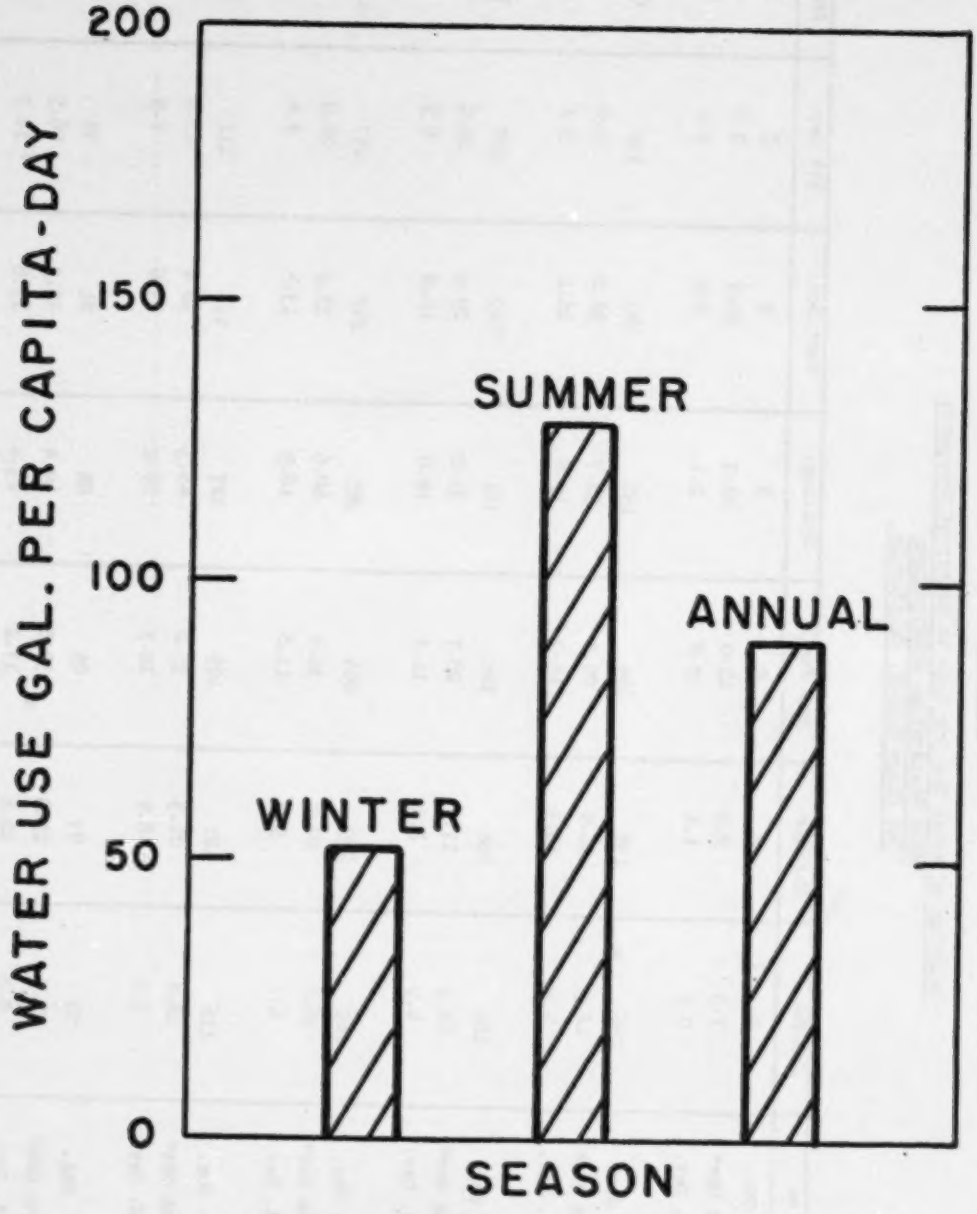
Winter	$Q = 89 + 28\ P$
Summer	$Q = 336 + 43\ P$
Annuel	$Q = 207 + 34\ P$

where:

Q is mean water use in gallons per home per day,

P is the number of home occupants.

The intercept which represents water use not directly related to person occupancy is about four times greater for the summer equation than for the winter equation.



WATER USE BY SEASON
SAN DIEGO CO., CAL.

FIGURE 10

Table 12

Relation of Water Use per Home to Number of Occupants
Many Residential Subdivisions
San Diego County, California

Persons	Item	Jan.Feb.	Mar.Apr.	May Jun.	Jul.Aug.	Sept.Oct.	Nov.Dec.	Annual
	No. Obs.	3	2	2	3	3	3	16
1	Mean Use*	7.3	9.0	15.0	15.3	10.7	8.7	10.9
	Std. Dev.	0.6	1.4	2.8	2.1	2.9	2.5	3.7
	No. Obs.	136	138	144	150	140	132	840
2	Mean Use*	12.3	16.9	29.5	36.7	30.0	16.0	23.9
	Std. Dev.	5.6	10.3	14.9	19.6	16.1	9.2	16.3
	No. Obs.	162	166	165	161	149	152	955
3	Mean Use*	14.3	17.9	28.7	35.8	29.9	16.9	23.9
	Std. Dev.	4.9	8.3	11.5	14.8	12.8	6.9	13.1
	No. Obs.	262	259	264	265	248	247	1545
4	Mean Use*	16.0	20.0	32.4	40.6	33.9	20.0	27.2
	Std. Dev.	6.1	9.2	11.8	16.9	13.4	9.4	14.7
	No. Obs.	116	121	125	127	114	111	714
5	Mean Use*	18.8	21.3	35.0	45.3	38.4	22.0	30.4
	Std. Dev.	7.0	8.9	12.5	16.2	13.6	7.9	15.3
	No. Obs.	78	83	85	88	81	76	491
6	Mean Use*	21.9	25.0	39.5	49.4	42.3	26.5	34.5
	Std. Dev.	7.7	12.6	17.2	23.4	17.8	14.7	19.3

*Hundreds of Cubic Feet per two months.

Santa Clara County, California

Santa Clara County is located in central California at the southern tip of San Francisco Bay. The climate is variable due to the influence of rapid elevation changes and the Pacific Ocean. Mean annual rainfall in the residential areas ranges from 14 to 30 inches, and the average potential evapotranspiration is about 27 inches. The average growing season ranges from 250 to 320 days.

Water use data were obtained for 21 homes scattered throughout the residential suburbs of the County. Landscaping of lots, home size, and use of special water-using appliances varied considerably since the homes were not located in subdivisions with similar building patterns.

Seasonal water use is shown graphically in Figure 11. Winter is represented by December, January, and February, while summer is represented by June, July, and August. Use in the summer season is four times as great as use in the winter season.

Mean water use data for six person-occupancy classes are presented in Table 13. These data show a strong relationship between water use and person-occupancy. Linear water use equations, derived from the data in Table 13, are:

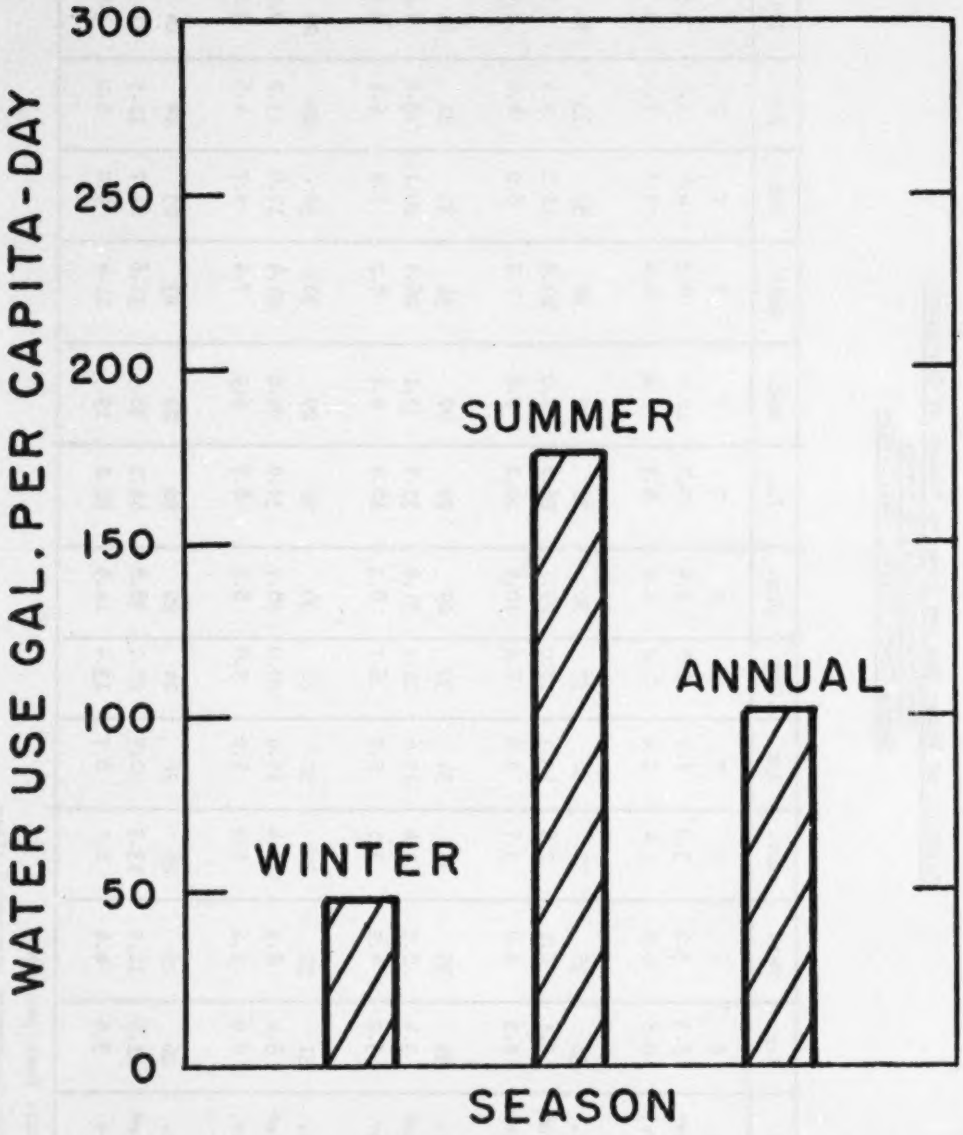
Winter	$Q = 41 + 40\ P$
Summer	$Q = 223 + 122\ P$
Annual	$Q = 130 + 72\ P$

where:

Q is mean water use in gallons per home per day,

P is the number of home occupants.

Annual water use data for 12 or more homes were available over the period from 1951 through 1956. The average number of occupants increased from 4.0 to 4.5 during this period. Mean annual monthly water use per home ranged from a low of 1640 cubic feet in 1951 to a high of 1950 cubic feet in 1953. Neither the high or low are significantly different from the over-all mean of 1810 cubic feet per home per month.



WATER USE BY SEASON
SANTA CLARA CO., CAL.

FIGURE 11

Table 13

Relation of Water Use per Home to Number of Occupants
Twenty-one Suburban Homes
Santa Clara County, California

Persons	Item	Jan.	Feb.	Mar.	Apr.	May	Jun.	Jul.	Aug.	Sept.	Oct.	Nov.	Dec.	Annual
2	No. Obs.	6	6	6	7	6	5	7	7	7	7	7	7	78
	Mean Use*	3.3	3.2	3.3	5.4	5.5	6.4	10.7	10.4	8.3	6.4	4.9	3.9	6.1
	Std. Dev.	0.8	0.8	1.4	2.4	1.2	1.1	8.3	5.9	4.4	3.5	2.6	0.7	4.3
3	No. Obs.	35	35	35	36	32	30	31	32	32	32	33	33	396
	Mean Use*	6.5	6.1	7.8	13.3	17.0	25.1	26.8	24.0	20.8	15.1	9.4	6.7	14.6
	Std. Dev.	2.5	2.0	3.7	5.8	7.6	10.5	10.2	9.6	7.7	6.2	4.0	2.4	9.9
4	No. Obs.	35	35	35	34	30	29	29	29	31	31	31	31	380
	Mean Use*	9.4	8.7	9.4	15.6	22.2	31.8	35.5	33.1	26.5	20.1	13.8	9.6	19.1
	Std. Dev.	3.2	4.2	3.5	5.7	6.1	8.3	10.0	9.1	8.2	7.2	5.1	3.2	11.5
5	No. Obs.	31	32	32	32	28	30	29	29	30	30	29	29	361
	Mean Use*	8.4	8.3	9.4	15.6	20.0	28.7	30.0	26.6	24.4	17.8	13.2	9.2	17.5
	Std. Dev.	2.9	2.6	3.2	5.2	5.8	8.5	8.7	6.9	7.4	5.7	4.5	3.2	9.7
6 or over	No. Obs.	26	26	26	26	24	22	22	22	23	23	24	24	288
	Mean Use*	11.6	11.5	13.5	20.5	28.1	38.8	44.1	38.5	31.6	21.7	15.5	11.3	23.2
	Std. Dev.	3.6	4.4	8.1	8.7	13.4	14.9	20.2	19.5	11.4	9.0	5.2	3.6	15.8

*Hundreds of Cubic Feet per month.

Note: No data for one-person occupancy class.

Wyandotte County, Kansas

Wyandotte County is in the northeastern corner of Kansas at a boundary of humid and subhumid climatic regions. Mean annual rainfall is 36 inches, and mean annual potential evapotranspiration is about 31 inches. Monthly potential evaportranspiration exceeds monthly rainfall for about five months during the summer. The average growing season of 205 days starts in early April and ends in late October.

Water use data were obtained for 167 homes from 6 subdivisions. Lot sizes, home size, and style, and landscaping were variable between subdivisions. Food waste grinders were the only special water-using appliances which were used extensively. About one-third of the homes were equipped with this appliance.

Mean water use by season is shown in Figure 12. Two bimonthly periods (December, January and February, March) were chosen to represent winter, and two bimonthly periods (June, July and August, September) were chosen to represent summer. Use in the summer season is about 50 percent greater than use in the winter season.

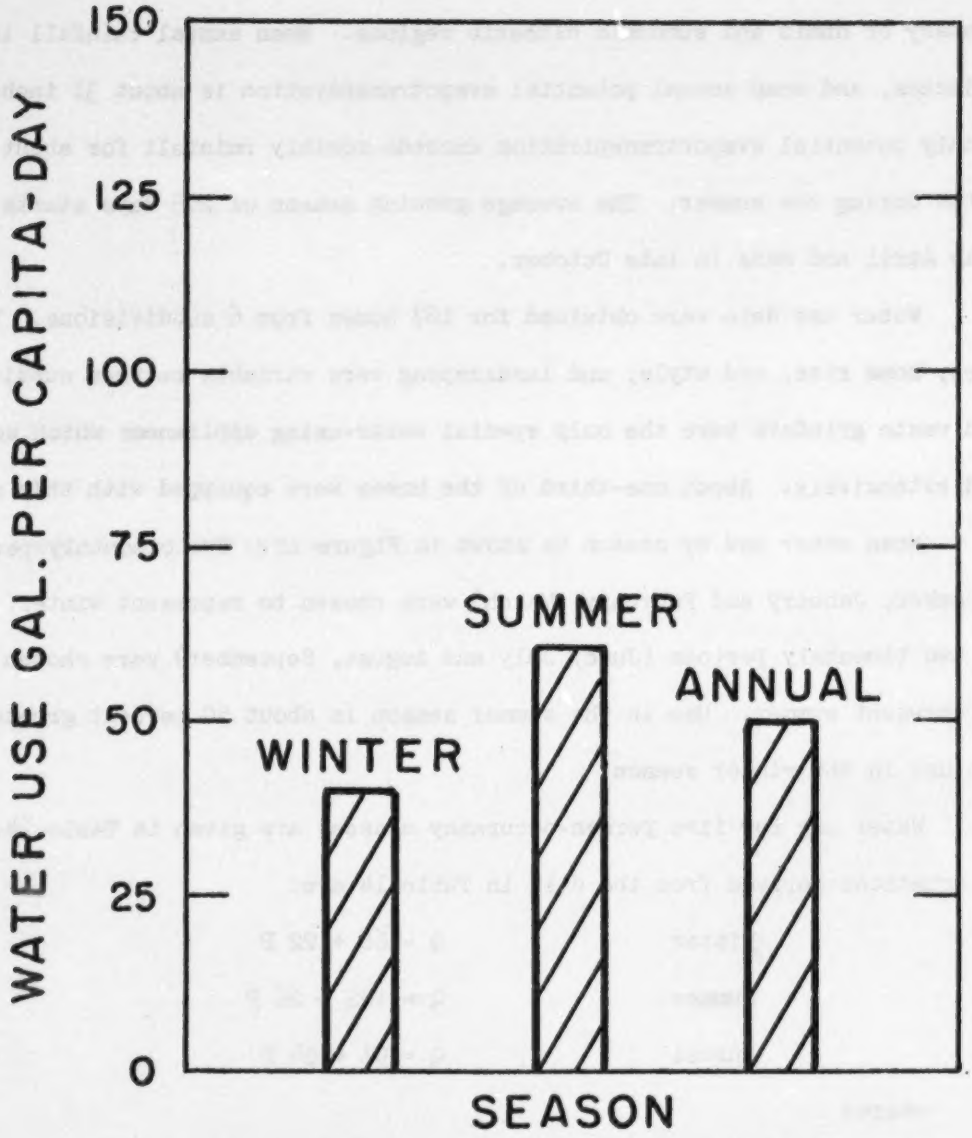
Water use for five person-occupancy classes are given in Table 14. Water use equations derived from the data in Table 14 are:

Winter	$Q = 66 + 22\ P$
Summer	$Q = 122 + 26\ P$
Annual	$Q = 91 + 24\ P$

where:

Q is mean water use in gallons per home per day,

P is the number of home occupants.



WATER USE BY SEASON
WYANDOTTE CO., KANS.

FIGURE 12

Table 14

Relation of Water Use per Home to Number of Occupants
Five Residential Subdivisions
Wyandotte County, Kansas

Persons	Item	Dec.Jan.	Feb.Mar.	Apr.May	Jun.Jul.	Aug.Sept.	Oct.Nov.	Annual
	No. Obs.	92	100	106	109	82	88	577
2	Mean Use*	9.2	9.0	11.6	14.7	15.3	11.5	11.9
	Std. Dev.	3.9	3.9	6.4	8.9	6.0	7.9	7.8
	No. Obs.	115	122	126	128	92	106	689
3	Mean Use*	10.1	10.2	12.7	15.9	14.7	12.1	12.6
	Std. Dev.	3.6	3.7	6.7	8.0	7.8	6.5	6.6
	No. Obs.	102	113	122	133	98	98	666
4	Mean Use*	13.3	12.9	15.8	18.9	18.1	15.3	15.8
	Std. Dev.	4.8	4.5	7.3	12.0	8.9	7.1	8.3
	No. Obs.	60	66	72	78	50	58	384
5	Mean Use*	16.6	15.8	18.1	20.8	21.1	16.5	18.2
	Std. Dev.	7.7	7.4	5.8	7.7	10.8	7.6	8.0
	No. Obs.	43	44	47	51	37	40	262
6	Mean Use*	14.3	14.6	18.1	21.9	24.3	16.3	18.2
	Std. Dev.	6.1	6.5	9.4	11.7	14.1	8.8	10.4

*Hundreds of Cubic Feet per two months.

Note: No data for one-person occupancy class.